

Lightning Imaging Sensor on International Space Station

S. Pavelitz¹ and R. J. Blakeslee

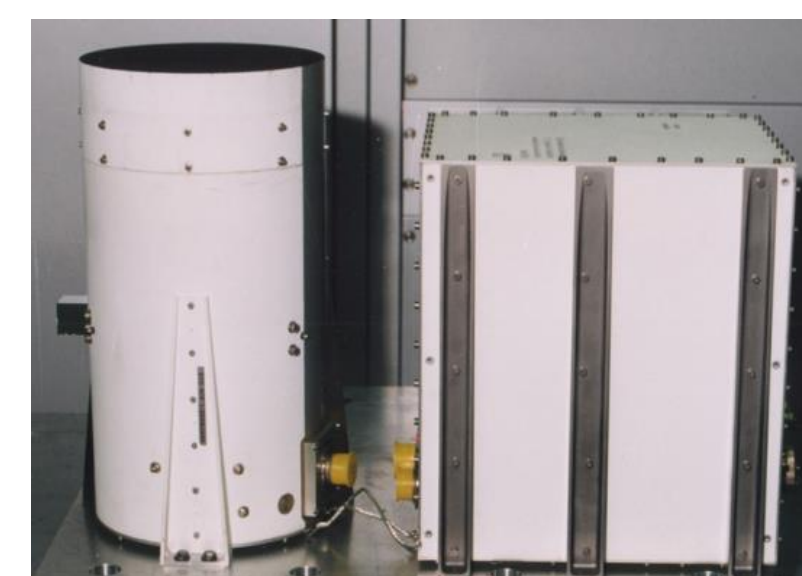
¹NASA Marshall Space Flight Center (email: Steven.D.Pavelitz@nasa.gov, phone: 256-961-7462)

Presentation: 2016-Poster-1-23

Introduction and Overview

Mission

- Fly a space-qualified, flight-spare LIS on ISS to take advantage of unique capabilities provided by the ISS (e.g., high inclination, real time data).
- Integrate LIS as a hosted payload on the DoD Space Test Program-Houston 5 (STP-H5) mission and launch on a Space X rocket in June 2016 for a minimum 2 year mission.



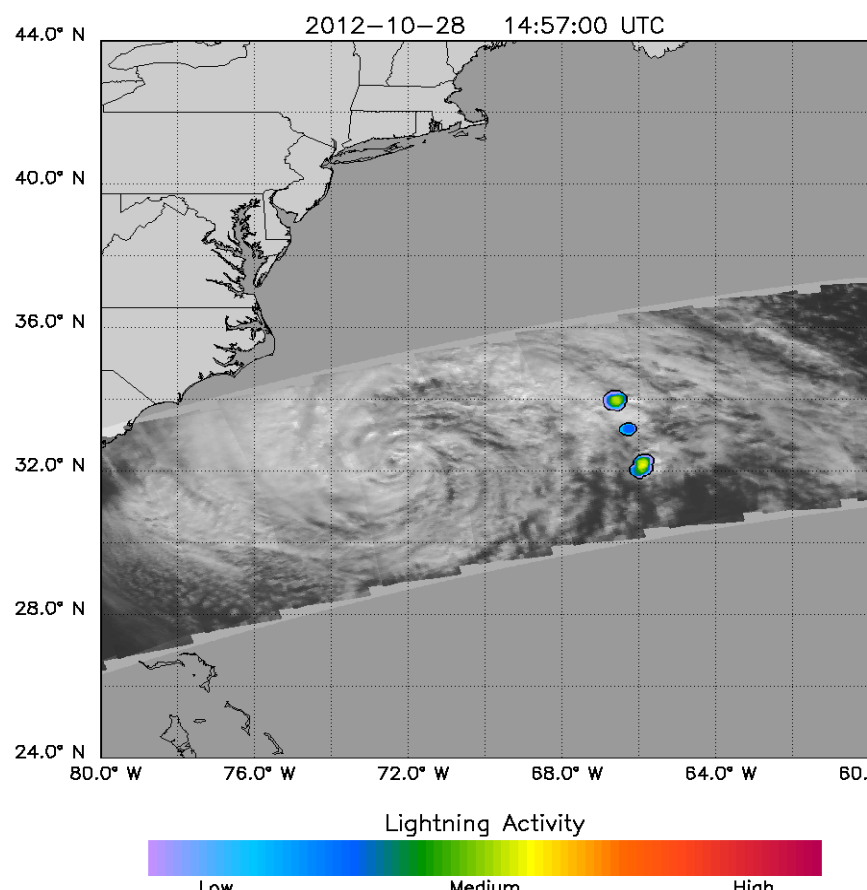
Flight Spare LIS

Measurement

- NASA and its partners developed and demonstrated effectiveness and value of space-based lightning observations as a remote sensing tool.
- LIS measures total lightning (amount, rate, radiant energy) during both day and night, with storm scale resolution, millisecond timing, and high, detection efficiency.
 - LIS daytime detection is especially unique and scientifically important (>70% occurs during day).
 - Also, LIS globally detects TOTAL (both cloud and ground) lightning with no land-ocean bias.

Need and Benefit

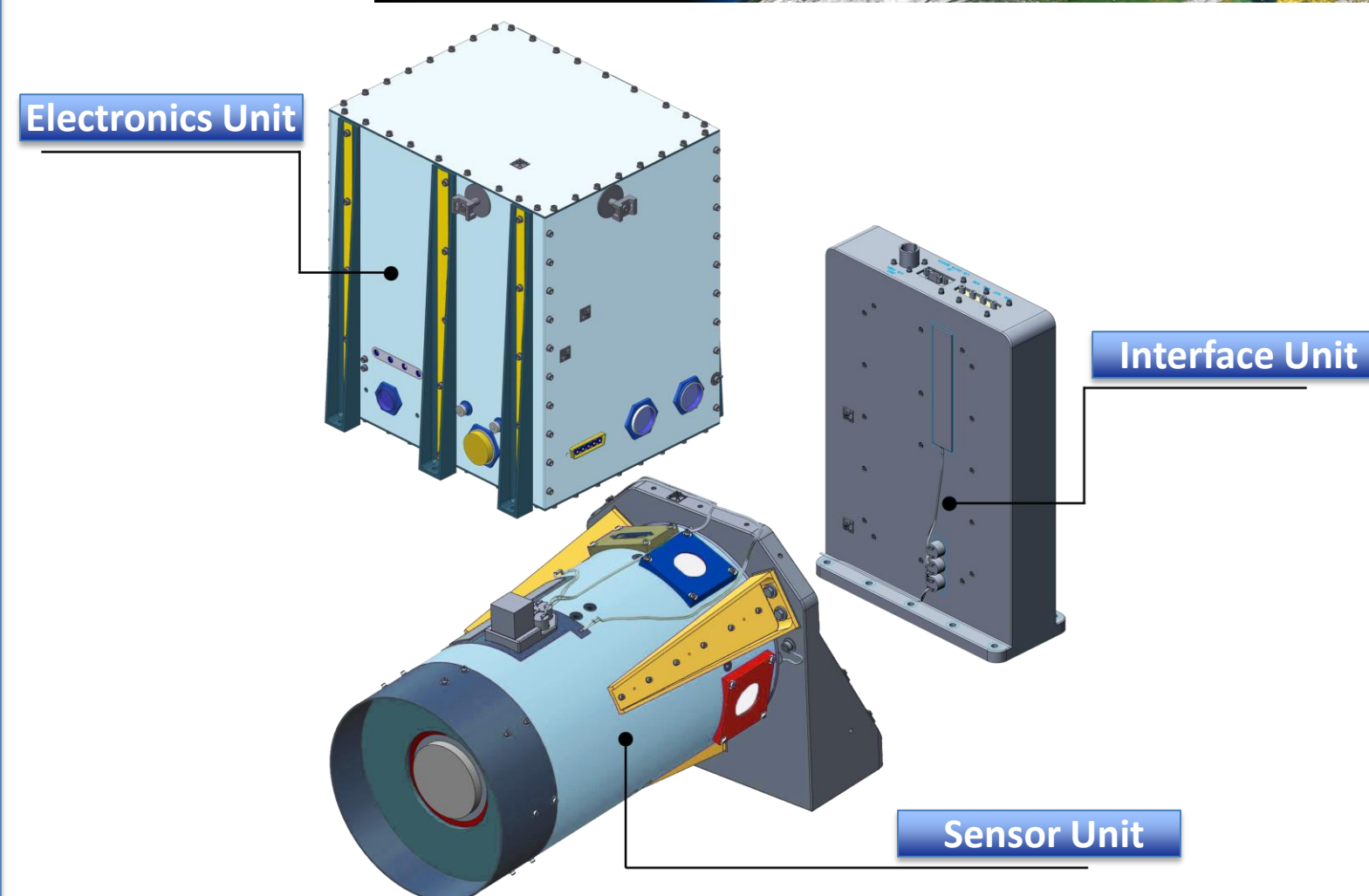
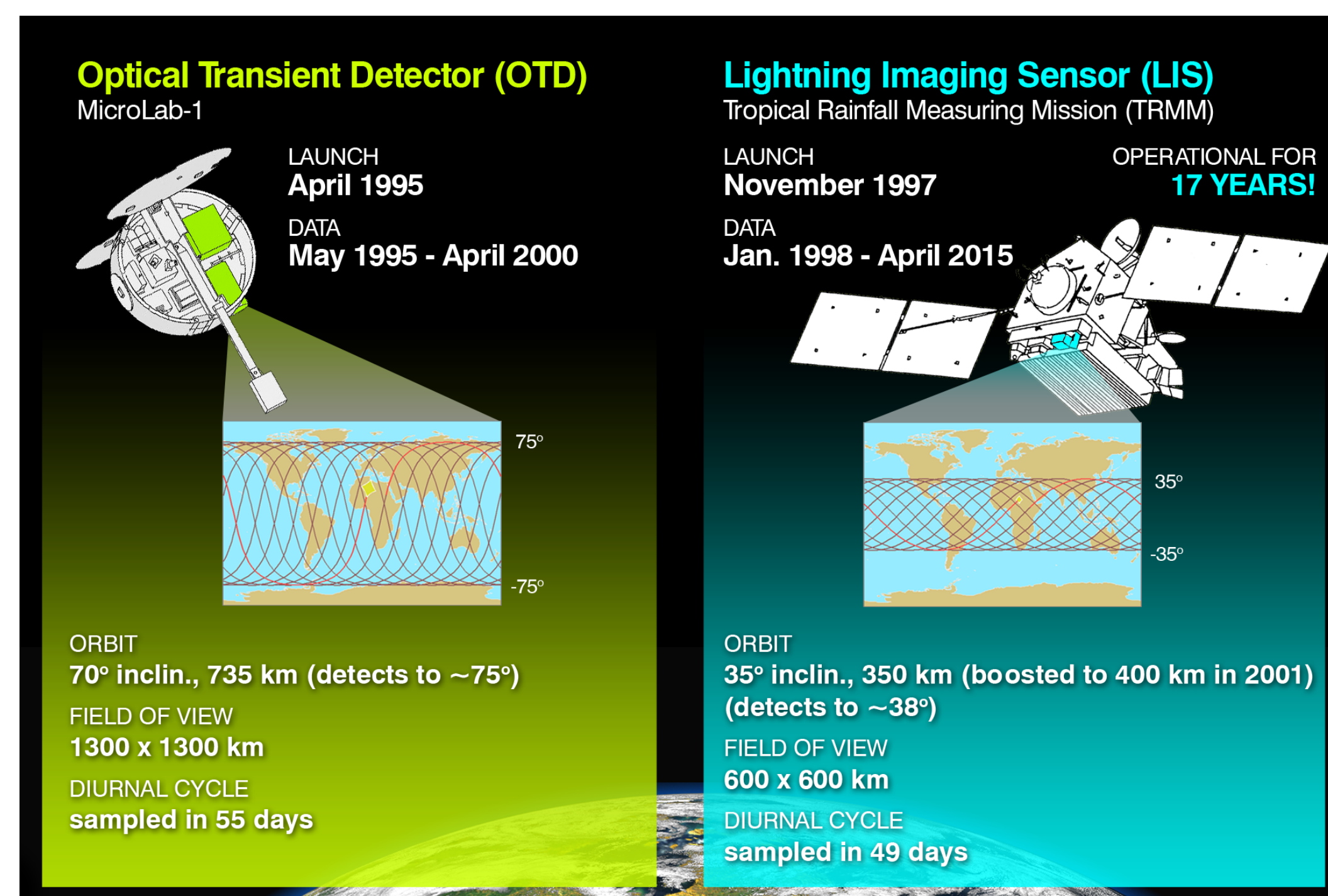
- Lightning is quantitatively coupled to both thunderstorm and related geophysical processes, and therefore provides important science inputs across a wide range of disciplines (e.g., weather, climate, atmospheric chemistry, lightning physics).
- LIS on ISS will extend TRMM time series observations, expand latitudinal coverage, provide real time data to operational users, and enable cross-sensor calibration.



LIS Lightning and Background Images (Super Storm Sandy October 28, 2012)

LIS Heritage (Flight, Infrastructure, Hardware)

- ISS LIS builds upon a solid foundation of 20 years on-orbit observations.
- Key LIS scientists, engineers, and facilities are still in place to support this mission.



Sensor Unit (legacy hardware)

- Optical Assembly
- 128x128 CCD Focal Plane
- Lightning and Background detection

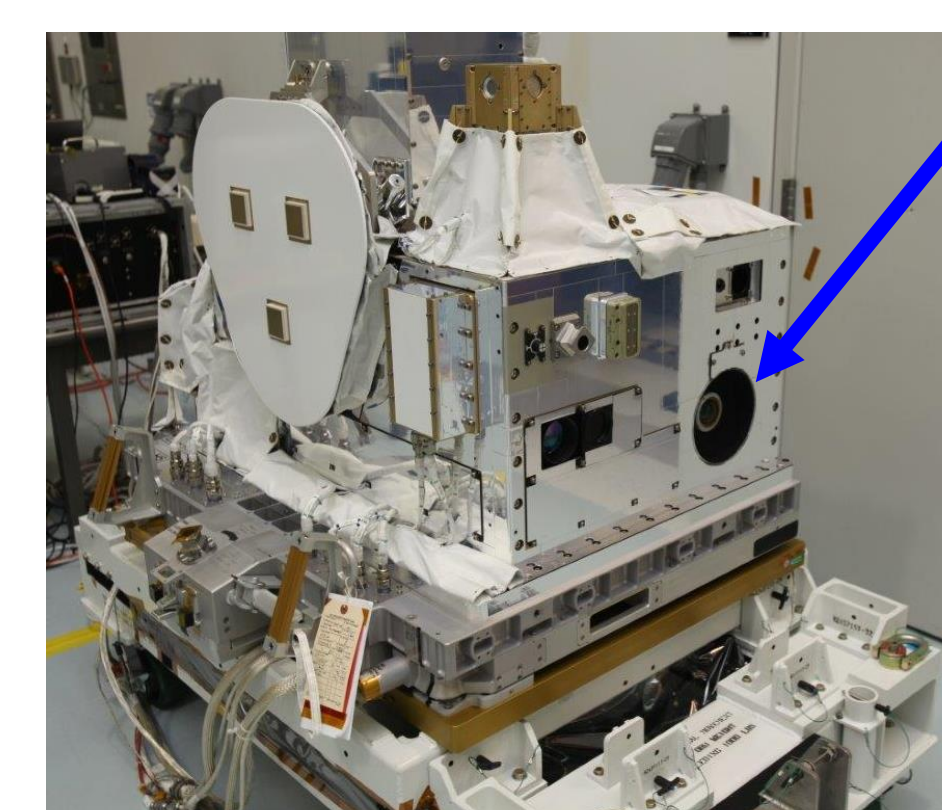
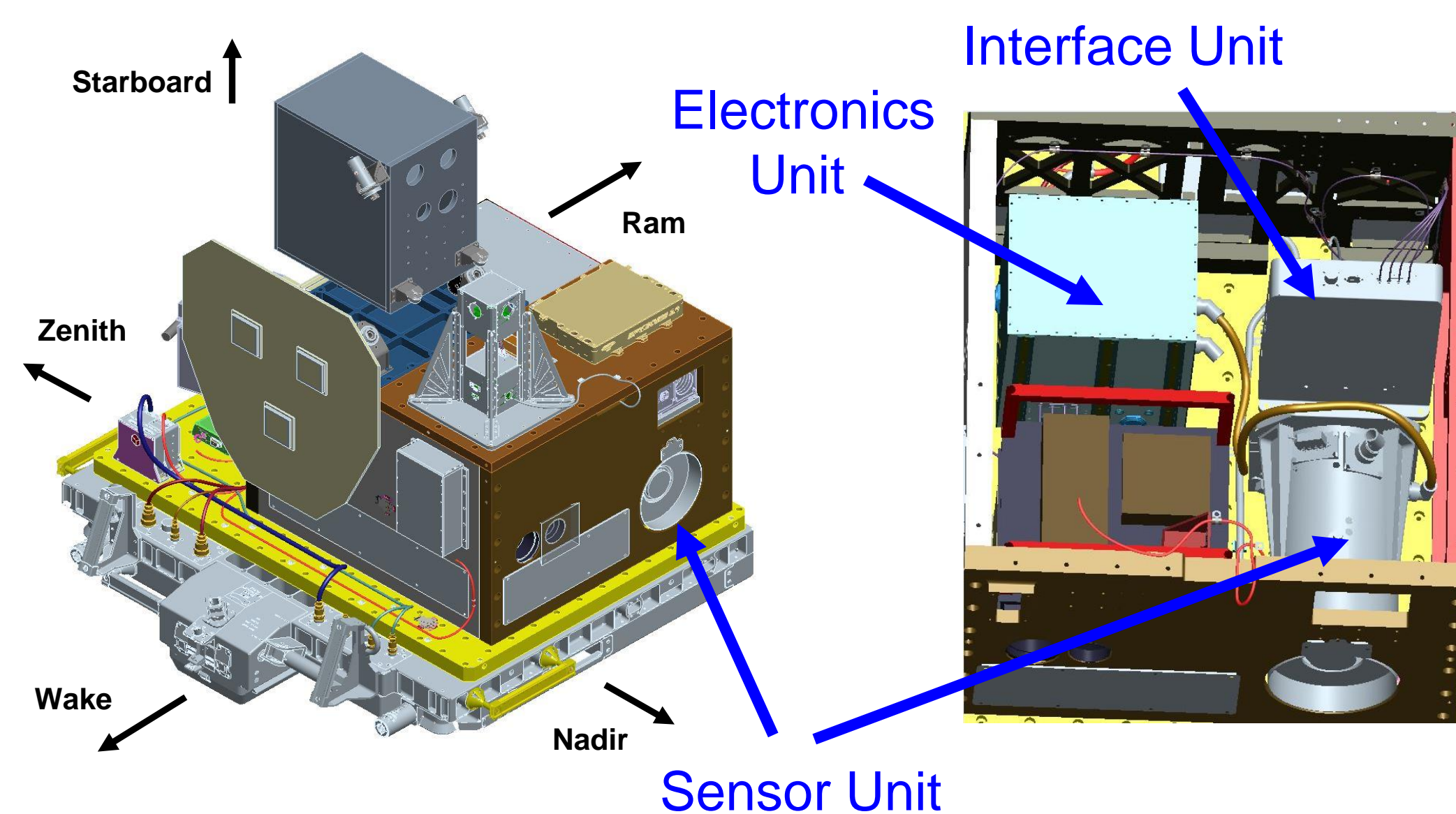
Electronics Unit (legacy hardware)

- Real Time Event Processor, Background removal, Data formatting
- Power conversion and control

Interface Unit (new hardware)

- Power conversion, Timing, Control
- ISS Interface

LIS Integration as Hosted Payload on STP-H5



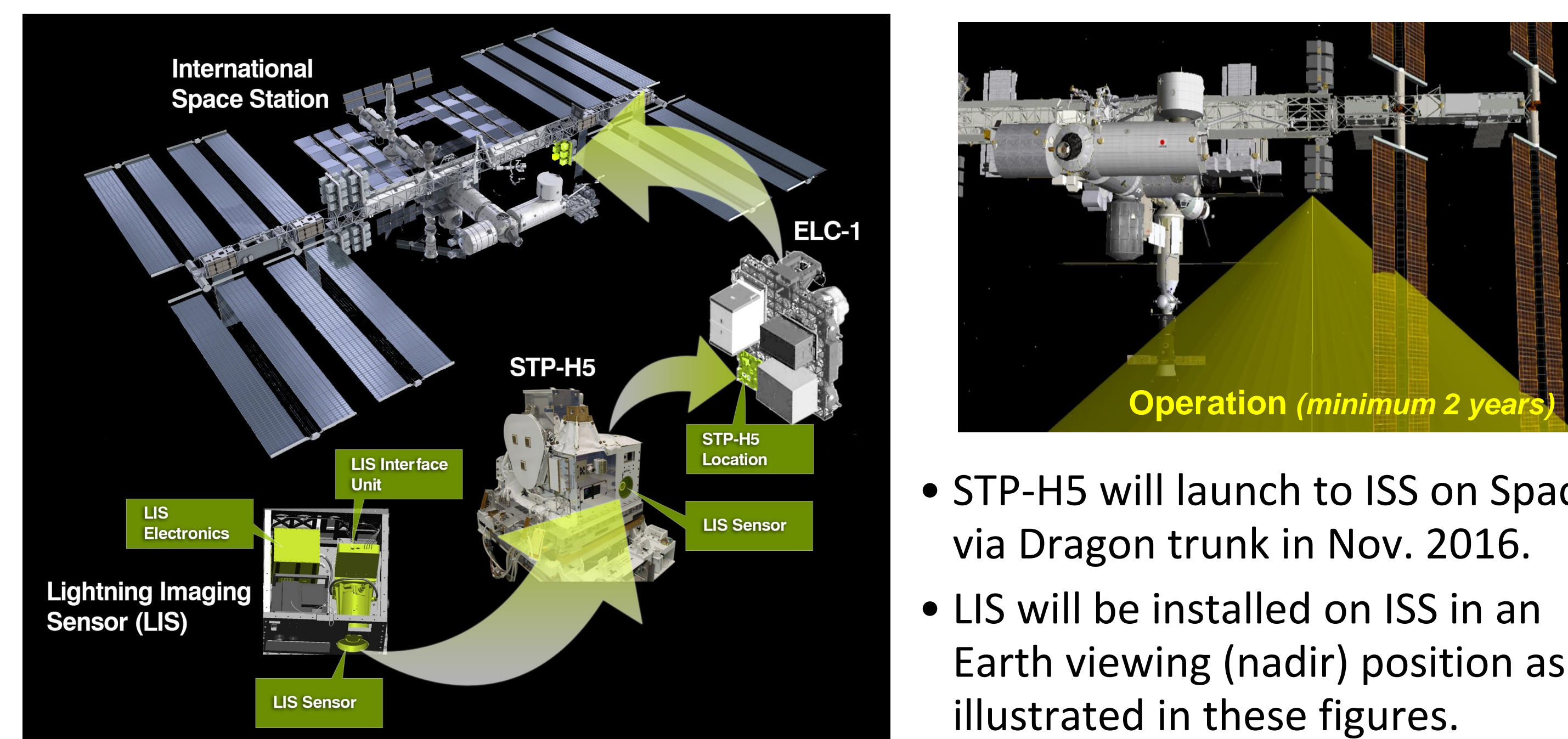
STP-H5 Payload

Field-of-View (FOV)	80° × 80°	Measurement Accuracy	
Pixel IFOV (nadir)	4 km	location	1 pixel
Interference Filter		intensity	10 %
wavelength	777.4 nm	time	tag at frame rate
bandwidth	1 nm	Dimensions	
Detection Threshold	4.7 μJ/m²sr	sensor unit	7.8 × 14.6 in (20 × 37 cm)
Signal-to-Noise Ratio	6	electronics unit	12.2 × 8.7 × 10.6 in (31 × 22 × 27 cm)
CCD Array Size	128 × 128	interface unit	9.8 × 2.4 × 13.8 in (25 × 6 × 35 cm)
Dynamic Range	> 100	Weight	55 lbs (25 kg)
Detection Efficiency	~ 90%	Power	35 W
False Event Rate	< 5 %	Telemetry Data Rate	8 kilobytes/second

LIS Performance Parameters

- LIS is one of thirteen instruments on the STP-H5 payload manifest.
- Payload built to allow robotic installation on ISS external truss as illustrated below.

LIS Launch and Installation Scenario

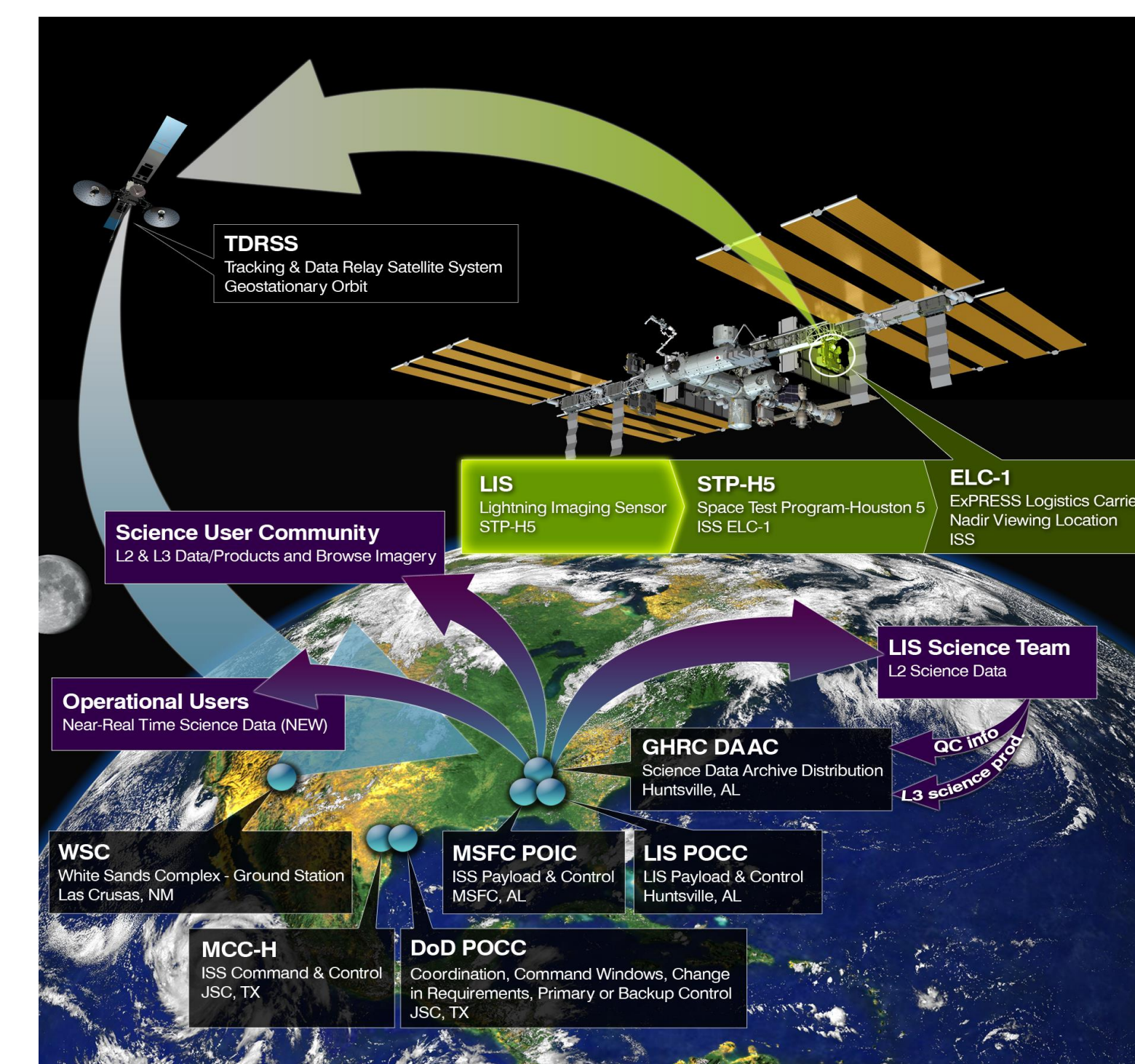


- STP-H5 will launch to ISS on Space X via Dragon trunk in Nov. 2016.
- LIS will be installed on ISS in an Earth viewing (nadir) position as illustrated in these figures.

Science Operations and Data Management



- Science operations will be managed from newly established LIS POCC.
- Data handling involves close partnership between LIS Science Team and GHRC DAAC.



Science and Applications from LIS Lightning

Weather: Total lightning is strongly coupled in a quantitative way to thunderstorm processes and responds to updraft velocity and cloud particles (concentration, phase, type, and flux).

- LIS acts like a radar in space: it reveals the heart of the cloud.
- Lightning can improve convective precipitation estimates.
- Lightning is strongly coupled to severe weather hazards (winds, floods, tornadoes, hail, wild fires) and can improve forecast models.

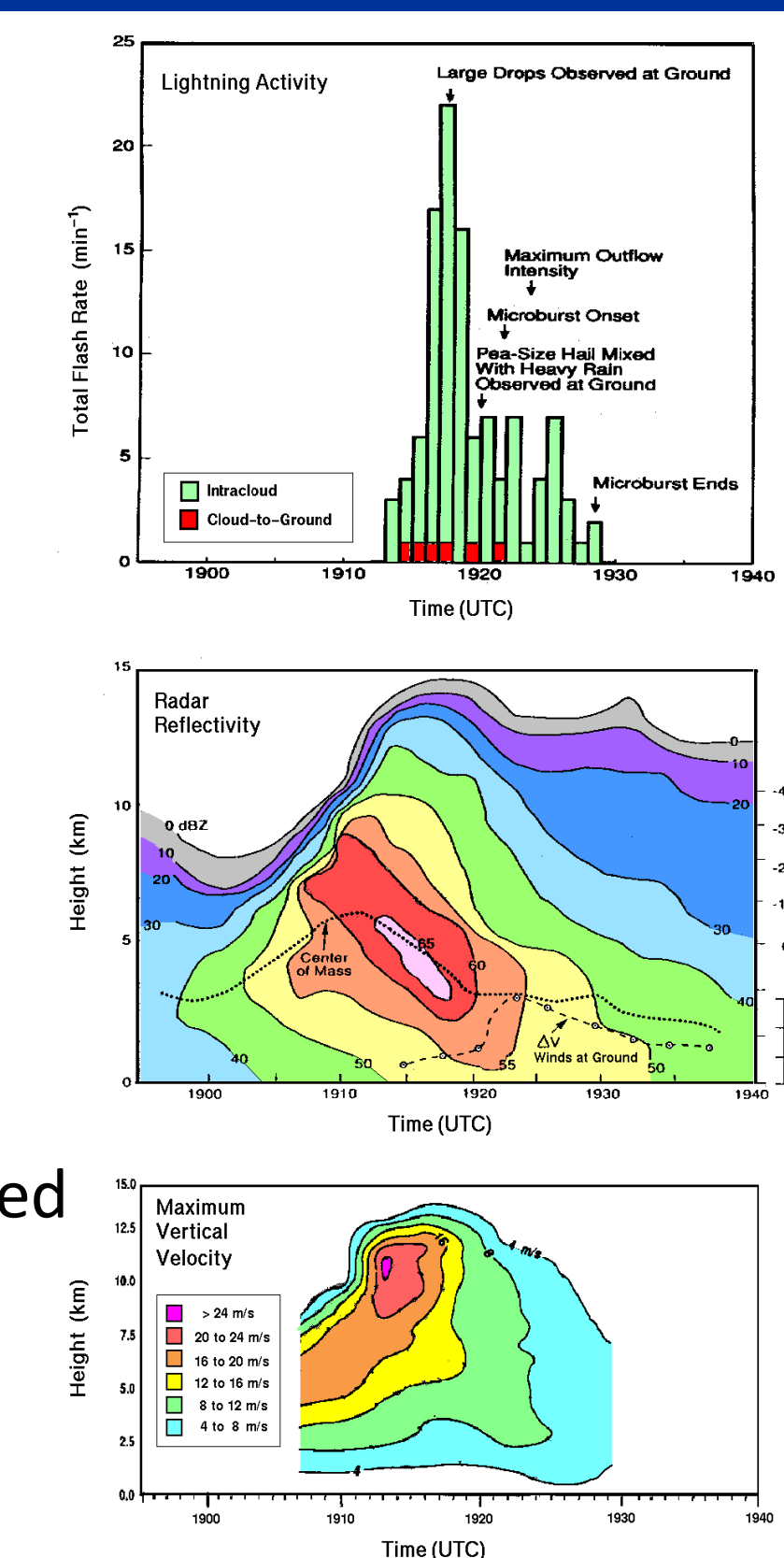
Climate: Lightning is an excellent variable for climate monitoring because it is sensitive to small changes in temperature and atmospheric forcing. ISS LIS will:

- Extend 16 year time series of TRMM LIS, expand to higher latitudes.
- Monitor the occurrence and changes in extreme storms.
- Provide much desired cross-sensor calibrations between platforms.

Chemistry: ISS LIS will help improve estimates of lightning produced NO_x for climate and air quality studies.

- Lightning NO_x also impacts ozone, an important green house gas.
- Climate most sensitive to ozone in upper troposphere, exactly where lightning is the most important source of NO_x.

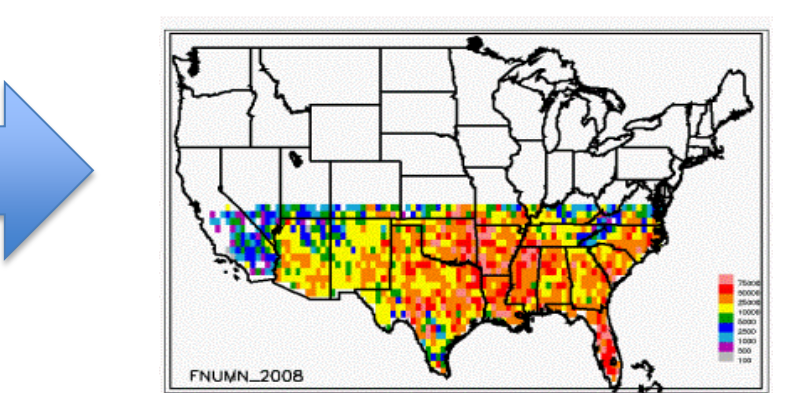
Other: Complementary ISS LIS observations will help unravel the mechanisms leading to terrestrial gamma-ray flashes (TGFs) and Transient Luminous Events (TLEs).



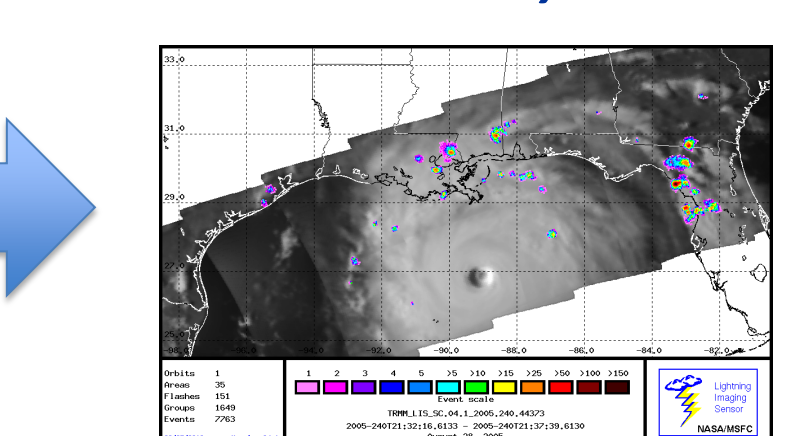
Lightning (top), radar (middle), and vertical velocity (bottom) illustrate strong lightning-storm coupling

Unique Science Contributions from ISS Platform

- Lightning coverage at higher latitude missed by TRMM
 - TRMM LIS missed up to 30% lightning in N. Hemisphere summer
 - Enhance regional and global weather, climate, and chemistry studies
 - Provide CONUS coverage (needed for the National Climate Assessment).
- Real time lightning using ISS for operational applications
 - Provide real time lightning in data sparse regions, especially oceans (storm warnings, nowcasts, oceanic aviation support, long-range lightning system validation, hurricane rapid intensification evaluations).
 - Desired by NASA and strongly endorsed by NOAA partners (partners include: NWS Pacific Region, Joint Typhoon Warning Center, Ocean Prediction Center, Aviation Weather Center, and National Hurricane Center).
- Enable simultaneous / complementary observations with other ISS payloads
 - Provide critical daytime lightning to better understand mechanisms leading to TGFs and TLEs (strongly endorsed by ESA ASIM).
- Support cross-sensor calibration and validation activities
 - Inter-calibrate ISS LIS with GOES-R GLM and MTG LI for improved science and applications (strongly endorsed by NOAA and ESA).



TRMM LIS did not cover CONUS for climate and chemistry assessments

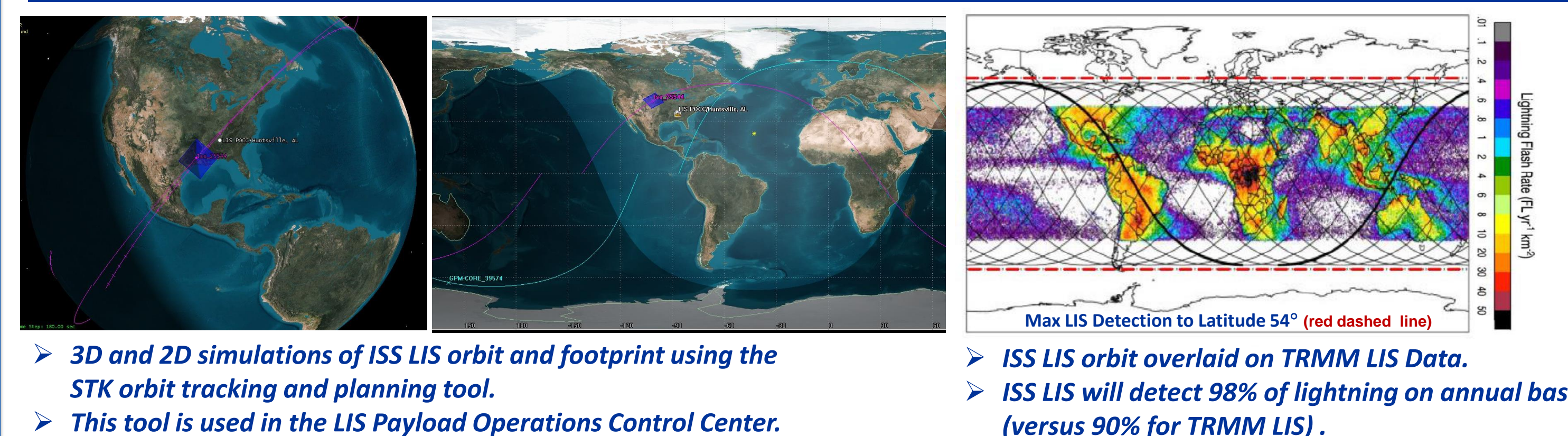


Real time lightning useful for operations (LIS in Hurricane Katrina)



GOES-R Geostationary Lightning Mapper based on LIS heritage

Global Coverage of LIS on ISS



- 3D and 2D simulations of ISS LIS orbit and footprint using the STK orbit tracking and planning tool.
- This tool is used in the LIS Payload Operations Control Center.

- ISS LIS orbit overlaid on TRMM LIS Data.
- ISS LIS will detect 98% of lightning on annual basis (versus 90% for TRMM LIS).

Summary

- LIS on ISS will continue the cross-disciplinary support of high-value science and applications begun with OTD and LIS on TRMM.
- The project will leverage data-handling infrastructure from TRMM to quickly deliver high-quality LIS data to users once operations begin
- LIS remains the "gold standard" for understanding global lightning climatology.